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Michael Landesmann and Robert Stehrer

**Global Growth Processes: Technology
Diffusion, Catching-up and Effective
Demand**

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**Global Growth Processes:
Technology Diffusion,
Catching-up and
Effective Demand**

Abstract

This paper analyses two issues that were characteristic of the global growth processes of the 1980s and 1990s: (i) there was an important diffusion process of a new general purpose technology (GPT) and (ii) there was a speed-up of catching-up of a sub-group of developing economies (South East Asia, later China and India) in an era of increasing globalization. Both these factors should in principle have given a boost to global economic growth; however, for quite some time, actual growth has been perceived as being in a more precarious state in advanced economies than in the earlier post-war period.

This paper develops a dynamic model of integrated economies (through trade and FDI) which attempts to address the above developments. The model has Schumpeterian and Keynesian features in that it depicts the income distributional shifts which might accompany the diffusion processes of new technologies (Schumpeterian innovational rents) and discusses effective demand problems which can arise both as a result of income distributional changes on the one hand and catching-up processes on the other. The paper starts with the stylized description of a competitive situation between two sets of advanced economies (say, the US and the EU) which are characterized by different behavioural responses in labour and product markets and where one region (the US) experiences the diffusion process of the new GPT earlier than the other region (the EU). The introduction of a new technology shifts the macro-distribution of income towards profits and the reliance of the growth process towards the investment (rather than consumption) component of effective demand. Differences in the workings of the labour and product markets affect the extent of these macro-distributional shifts. In addition the model is one in which the two sets of economies are integrated through trade and foreign direct investment flows. Transitory paths describe the impact of changing cost competitiveness and profitability positions upon net trade balances and net foreign direct investment flows. This amounts to leakages and injections in the two sets of economies which we track in terms of evaluating differences between 'potential' and 'actual' growth paths.

The second issue we try to analyse with the model is the impact of catching-up processes of a significant group of developing economies. Successful catching-up processes are characterized by fast productivity growth, by even stronger transitory wage-productivity growth gaps and hence macro-distributional shifts. This has implications for international direct investment flows and for global effective demand structures with the added dimension that the weight of the group of catching-up economies in the global economy is growing rapidly, which in turn affects the response mechanisms in the advanced economies. The focus remains on the exploration of the impact that different behavioural characteristics of labour and product markets have on the growth paths of the two sets of economies. The model allows for endogenous exchange rate dynamics, some endogeneity of productivity growth and changing international 'sourcing' patterns of intermediate inputs.

Keywords: international competition, catching-up, technology diffusion, Schumpeterian and Keynesian dynamics, dynamic modelling

JEL classification: E1, E12, E22, E25, F43, O11, O19, O41

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GLOBAL GROWTH PROCESSES: TECHNOLOGY DIFFUSION, CATCHING-UP AND EFFECTIVE DEMAND

Michael A. Landesmann and Robert Stehrer ¹

1 Introduction

This paper analyses a number of issues that were characteristic of the growth processes of advanced economies in the 1980s and 1990s: (i) there was an important diffusion process of a new general purpose technology (GPT), i.e. information technology; (ii) as a broad characterization, one can say that the US took on the role as an 'innovator' in introducing this GPT with Europe broadly following; (iii) there was a speed up of catching-up of a sub-group of developing economies (South East Asian, later China and India) in an era of increasing globalization. Both factors (i) and (iii) should in principle have given a boost to global economic growth; however, for quite some time, it looks as if actual growth is in a more precarious state in advanced economies than in the earlier post-war period.

The paper develops a dynamic model of integrated economies (through trade and FDI) which attempts to address the above developments. The model has Schumpeterian and Keynesian features in that it depicts the income distributional shifts which might accompany the diffusion processes of new technologies (emergence of Schumpeterian innovational rents) and discusses effective demand problems which can arise both as a result of income distributional changes on the one hand and catching-up processes on the other.

The paper starts with the stylized description of a competitive situation between two sets of advanced economies (say, the US and the EU) and in which one region (the US) experiences the diffusion process of the new GPT earlier than the other region (the EU). The introduction of a new technology shifts the macro-distribution of income towards profits and the reliance of the growth process towards the investment (rather than consumption) component of effective demand. Characteristics in the workings of the labour and product markets affect the extent of these macro-distributional shifts. The shifts are transitory in that the Schumpeterian 'rent' component gets eroded over time (through wage claims and price-cost adjustment processes), but in the transitory period they have two effects: one, the accumulation rate and hence the production potential gets boosted (and, in addition, productivity growth can be further - endogenously - stimulated); two, the greater dependency of effective demand upon spending out of profits might increase the possibility of a 'leakage' which is modelled in the form of investment into liquid (non-interest-bearing) assets. Hence the transitory dynamic can significantly affect the balance between potential and actual growth through its impact upon the level of effective demand.

The important addition in this paper compared to an earlier paper (Landesmann and Stehrer, 2002) is that it deals with the accumulation and transitory dynamic in an open

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economy setting, allowing for the interaction between two large sets of economies. In this paper we shall use the model both to analyse the relationship between two sets of advanced economies (the EU and the US; in terms of points (i) and (ii) above), as well as to study the interaction between the group of advanced economies and a (significant) group of catching-up economies (see point (iii) above). These two applications of the model will be explored in sections 4 and 5 of the paper.

2 The model

As mentioned above, we model in this paper the interaction between two sets of economies. These are integrated through trade and foreign direct investment flows, as well as through interdependent price and exchange rate dynamics. Transitory paths describe the impact of changing cost competitiveness and profitability positions upon net trade balances and net foreign direct investment flows. Uneven rates of technology diffusion and ensuing price-cost dynamics affect the relative attractiveness of different locations for direct investments and the relative competitiveness of trading partners both in final demand as well as in the international 'sourcing' of intermediate inputs and capital equipment. The dynamics of capacity growth is driven by investment flows (determined by relative profitability), while the dynamics of output growth is driven by demand growth (determined by the expansion of demand components which are sensitive to relative price movements). This leads to potential 'output gaps' (i.e. differences between potential and actual output).

Net trade balances, foreign direct investment flows and investments into liquid (non-interest bearing) assets amount to the international transmission of leakages and injections in the two sets of economies. They impact upon the differences between 'potential' and 'actual' growth paths. The interesting point that we analyse in discussing the interaction between the two large economies is that the speed of technology diffusion and its impact upon macro-distribution and growth is significantly affected by the degree of international interdependence. This applies both to the interaction between advanced economies which are characterized by different and changing speeds in the introduction and diffusion of new technologies and to the interaction between (technologically) advanced and catching-up economies where the speed of technology transfer, together with distributional dynamics, determines interactively relative cost competitiveness and the dynamics of international investments.

The model described in the following is an extension of the model developed in Landesmann and Stehrer (2002) to a two-country case. It treats the issues in an aggregate framework, but most analytical results can also be obtained in a multi-sectoral setting (see Stehrer, 2002).

2.1 Technology

Technology is denoted by a pair of input coefficients \tilde{a}^c and a_l^c where \tilde{a}^c denotes the input coefficient of intermediate goods and a_l^c the input coefficient for labour. Superscript c denotes the respective country. The labour input coefficient a_l^c is assumed to be strictly

positive (thus we assume that some labour is always used in production). Labour productivity is then $1/a_l^c$. We shall take account of changes in labour productivity, but assume that the technological input coefficient \tilde{a}^c remains fixed.

On the other hand, we shall allow for substitution in the 'sourcing' of the input requirements across countries, i.e. inputs can be purchased in the domestic or the foreign country. This then implies a 'sourcing matrix' - in a two-country setting - to be given by

$$\mathbf{A} = [a^{rc}] = \begin{pmatrix} a^{11} & a^{12} \\ a^{21} & a^{22} \end{pmatrix}$$

with r representing the sourcing and c the destination country and $\sum_{r=1}^2 a^{rc} = \tilde{a}^c$. We shall discuss the determination of these coefficients below.

Labour input coefficients change according to the exploitation of an exogenously evolving technological potential. The evolution of the potential is modelled as a logistic curve, i.e.

$$\dot{a}_{l,pot}^c = g_{a_{l,pot}}^c (1 + k^c g_q^c) a_{l,pot}^c (1 - a_{l,pot}^c)$$

where $a_{l,pot}$ ($0 < a_{l,pot} \leq 1$) denotes the technological potential and $g_{a_{l,pot}}^c$ is a parameter which determines the speed by which an economy moves along the logistic. The labour input coefficients then evolve according to

$$\dot{a}_l^c = \left(1 - \frac{a_{l,0}^c - \bar{a}_l^c}{a_{l,0}^c} a_{l,pot}^c \right) a_{l,0}^c - a_l^c \quad (2.1)$$

where $a_{l,0}^c$ is the starting value of the labour input coefficient. This specification implies that labour input coefficients reach the (exogenously) given level \bar{a}_l^c , although the time path is determined by the logistic. Further, the growth rate of the logistics is (partly) endogenized by a Kaldor-Verdoorn effect or a Schumpeterian mechanism, k^c , and will become a function of the growth rate of output g_q^c or of innovational investments respectively.

2.2 Wages, costs and prices

Nominal variables are expressed in national currency units. At times we may convert them into a common currency. Let us denote the exchange rate between countries 1 and 2 by x^{12} . E.g. $p^1 x^{12}$ expresses price in country 1 in currency of country 2. Similarly $p^2 x^{21}$ is price in country 2 expressed in currency of country 1. We set $x^{cc} = 1$.

The (nominal) wage rate (in currency of country b) is denoted by $w^c x^{cb}$ and unit labour costs are given by $(v^c x^{cb}) = a_l^c (w^c x^{cb})$.

Total unit costs are then $(c^c x^{cb}) = \sum_{r=1}^2 (p^r x^{rb}) a^{rc} + a_l^c (w^c x^{cb})$. For prices we assume a country-specific (constant) mark-up π^c on costs; thus we have $(p^c x^{cb}) = (1 + \pi^c) (c^c x^{cb})$. This formulation implies that wages are paid at the beginning of the period, i.e. *ante factum*.

Price adjustment is modelled as a price to cost (plus normal mark-up) adjustment. In national currency units we assume the adjustment process given by

$$\dot{p}^c = -\delta_p^c [(1 + \pi^c)c^c - p^c] \quad (2.2)$$

with $0 < \delta_p^c \leq 1$ being the adjustment parameter. With $\delta_p^c < 1$ and a positive technology shock (a^c or a_l^c falling) rents emerge in addition to profits.²

The equilibrium of the price system can easily be determined for the case that coefficient a^{cr} , w^c , a_l^c and thus the unit labour costs v^c , and the mark-up ratio π^c are exogenously given and constant.

2.3 Profits and rents

The per-unit (equilibrium) profit is defined as a mark-up on costs. In national currency this is $r^c = \pi^c c^c$. In case that prices are not at the equilibrium level, there arise per-unit rents which are (again in national currency) defined as $s^c = p^c - (1 + \pi^c)c^c$. In the following we assume that part of the rents are distributed to the workers (denoted by κ_s^c) as discussed below. We define m^c as the addition of profits r^c and the part of rents s^c that is not distributed to workers $(1 - \kappa_s^c)s^c$ and refer to it as 'retained earnings',

$$m^c = r^c + (1 - \kappa_s^c)s^c. \quad (2.3)$$

2.4 Labour market dynamics

The (out-of-equilibrium) dynamics of the wage rate is modelled as follows:

$$\dot{w}^c = \kappa_s^c \frac{s^c}{a_l^c} + \kappa_u^c u^c w^c \quad (2.4)$$

where u^c denotes the unemployment rate $u^c = (h^c - l^c)/h^c$ with h^c and l^c referring to labour supply and labour demand respectively. We assume that $0 \leq \kappa_s^c \leq 1$ and $\kappa_u^c \leq 0$. The first term means that part of transitory rents are distributed to workers (i.e. compensating them for the increases in productivity) and the second term imposes a negative effect of unemployment on the growth of the nominal wage rate.

Labour supply h^c is modelled as

$$\dot{h}^c = \delta_h^c (l^c - h^c) + g_h^c h^c \quad (2.5)$$

where δ_h^c denotes a supply-to-demand adjustment parameter and g_h^c is an exogenously given growth rate of labour supply. We assume that

$$\delta_h^c = \begin{cases} \delta_{h,IN}^c > 0 & \text{if } l^c - h^c \geq 0 \\ \delta_{h,OUT}^c \geq 0 & \text{if } l^c - h^c < 0. \end{cases}$$

²This rather mechanic specification represents the Schumpeterian insight that technological innovations induce transitory changes in the market structures which accompany the introduction and diffusion of new technologies. The chosen specification focuses on the distributional implications of the macro-dynamics of technical change and does not derive the individual firms' pricing behaviour.

This formulation allows for an asymmetric adjustment of the actual participation rate to positive or negative excess demand for labour (in general, one would expect faster adjustment to positive excess demand and relatively slow adjustment to negative excess demand).

2.5 Demand components and total demand

Next we turn to the determination of output. Total supply/production is denoted by q^c . Demand consists of three different components: demand for (1) intermediate goods, (2) consumption goods, and (3) investment goods. We now discuss these in detail.

2.5.1 Demand for intermediate products

Demand for intermediate goods used in production is $\mathbf{A} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix}$. As mentioned above intermediate inputs can be purchased at home or abroad. As we are interested in looking at the demand on country c we shall specify sourcing structures from the point of view of those countries which may demand those inputs from country c ; these are the countries $r = 1, 2$. For given sourcing coefficients a^{cr} (r being the country demanding inputs from country c out of a group of potential suppliers $s = 1, 2$) the nominal share of total outlays on intermediate goods demanded from c is given by $(p^c x^{cr}) a^{cr} / \sum_{s=1}^2 (p^s x^{sr}) a^{sr}$ as for given sourcing coefficients this is analogous to a Leontief-technology.

How are the sourcing coefficients determined? We shall allow the sourcing coefficients to be dependent on prices. Using a CES specification we model the sourcing of intermediate inputs which country r purchases from country c as

$$\zeta^{cr} = ((p^c x^{cr})^{1-\sigma_\zeta^c} (\varrho_\zeta^{cr})^{\sigma_\zeta^c} \left(\sum_{s=1}^2 (p^s x^{sr})^{1-\sigma_\zeta^c} (\varrho_\zeta^{cr})^{\sigma_\zeta^c} \right)^{-1}. \quad (2.6)$$

As $\sum_s \zeta^{sr} = 1$ this formulation satisfies that $\sum_s \zeta^{sr} \tilde{a}^r = \sum_s a^{sr} = \tilde{a}^r$. The coefficients $\zeta^{cr} \tilde{a}^r = a^{cr}$ are the coefficients of the 'global sourcing matrix' \mathbf{A} defined above³. The parameter ϱ_ζ^{cr} can be considered a home-bias effect (in the case where $c = r$) or a 'regionalist' bias in cases where there are preferential trading arrangements between countries r and c .⁴ Total expenditures in nominal terms by country r on intermediate inputs is given by $\sum_{s=1}^2 (p^s x^{sr}) a^{sr} q^r$. Multiplying with the nominal expenditure share β^{cr} and dividing by the prevailing price in the source country, p^c , gives demand for intermediate inputs

³For $\sigma_\zeta^c = 1$ the formulation collapses to a Cobb-Douglas specification (i.e. constant nominal shares); $0 \leq \sigma_\zeta^c < 1$ implies inelastic demand ($\sigma_\zeta^c = 0$ implies a specific Leontief sourcing technology); in this particular formulation this implies at equal supply prices also equal shares in the purchasing from different sources; finally, $\sigma_\zeta^c > 1$ means elastic demand, and with $\sigma_\zeta^c \rightarrow \infty$ the goods are considered perfect substitutes.

⁴In the simulations we set the parameter ϱ_ζ^{cr} in such a way that at equal prices the share of expenditure is given by $(\varrho_\zeta^{cr})^{\sigma_\zeta^c}$.

from country r in country c

$$\frac{1}{(p^c x^{cr})} \frac{(p^c x^{cr}) a^{cr}}{\sum_{s=1}^2 (p^s x^{sr}) a^{sr}} \sum_{s=1}^2 (p^s x^{sb}) a^{sr} q^r$$

which simplifies to $a^{cr} q^r = \zeta^{cr} \tilde{a}^r q^r$. Summing up over all countries $r = 1, 2$ gives the total demand for intermediate inputs in country c , i.e. $\sum_{r=1}^2 a^{cr} q^r$.

2.5.2 Wage income

Workers earn a nominal wage rate w^c and thus total nominal wage income in country c is $w^c a_l^c q^c = w^c l^c$ as $l^c = a_l^c q^c$ is labour demand. In a classical fashion we assume that workers spend all their income on consumption. Consumers have to decide in which country to purchase the goods. Analogous to the specification above (see equation (2.6)) one arrives at the nominal share μ^{cr} spent on goods of country c in country r out of labour income. The parameters in the CES specification for trade in consumption goods are denoted by σ_μ^r for the elasticity of substitution and ϱ_μ^{cr} denotes again a preference parameter for trade in consumption goods between countries c and r . Demand for consumption goods produced in country c and purchased out of income in country r is then (expressed in the currency of country c) $\mu^{cr} (v^r x^{rc}) / p^c$ with $v^r = w^r a_l^r$. Thus, demand for consumption goods produced in country c is the sum of domestic demand and exports of consumption goods.

$$\begin{aligned} \begin{pmatrix} f^1 \\ f^2 \end{pmatrix} &= \begin{pmatrix} \mu^{11} (v^1 x^{1c}) / (p^1 x^{1c}) & \mu^{12} (v^2 x^{2c}) / (p^1 x^{1c}) \\ \mu^{21} (v^1 x^{1c}) / (p^2 x^{2c}) & \mu^{22} (v^2 x^{2c}) / (p^2 x^{2c}) \end{pmatrix} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix} \\ &= \begin{pmatrix} d_f^{11} & d_f^{12} \\ d_f^{21} & d_f^{22} \end{pmatrix} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix}. \end{aligned}$$

The matrix allocates spending from labour income in each country as demand for consumption goods for the supplying country. We denote the elements of this matrix by d_f^{cr} .

2.5.3 Income out of profits

A second component of demand is demand for investment goods financed out of profits and the ('retained') part of transitory rents which is not distributed to workers. The volume of profits and ('retained') rents arising in country c is given by $m^c q^c$. To provide for 'leakage' effects we shall allow for a share of these earnings to be invested in a (non-interest-bearing) financial asset either in the domestic country c or a foreign country s . We denote these shares by λ^{rs} with $\sum_r \lambda^{rs} \leq 1$.⁵ To calculate the demand for investment goods arising

⁵The analysis can be generalized to interest-bearing assets. Since the focus of this paper is not on long-run transversality conditions with respect to financial asset accumulation and decumulation but rather on the effect of 'leakages' for transitory dynamics, we do not further explore the relationship between real and financial asset accumulation. In the simulations below we set the shares λ^{rs} equal to the investment shares ν^{rs} . See, however, Landesmann and Stehrer (2002) where the accumulation and decumulation of financial assets is explicitly taken into account.

from these earnings we have to specify, first, in which country these earnings are invested and, second, in which country the goods are purchased. To address the first question we again use a CES specification with the inverse of the retained (per-unit) earnings instead of prices. Parameters are denoted by ϱ_{ν}^{rs} and σ_{ν}^s , respectively. A specific country s invests in country r depending on its relative per-unit profitability (i.e. per-unit retained earnings); the (nominal) share ν^{sr} is denoted by ν^{rs} .⁶ The nominal sum which is invested in country r is then given by multiplying the shares with the volumes of retained earnings $m^s q^s$, and summing up over all countries s , we get $\sum_{s=1}^2 \nu^{rs} \left((1 - \sum_t \lambda^{ts}) (m^s x^{sc}) \right) q^s$. Once we have specified where investments (out of retained earnings) are taking place we have to specify, in a second step, in which country the demand for investment goods is taking place. We assume that this is determined by relative prices. For foreign direct investment we assume that the investor takes over the technology (i.e. as specified by the labour input coefficients and the inputs per unit of output requirements) prevailing in the host country; we shall later on discuss the possibility of a technology transfer through FDI. As regards sourcing of inputs, two possibilities arise:

FIRST CASE: In the first case the investor applies the same sourcing structure as that prevailing in the host country. The nominal sum invested from (the retained earnings received in) country s into country r is allocated to suppliers of investment goods as is indicated by the parameters ζ^{cr} above; thus in this case we have $\zeta^{cr} = \xi^{cr}$ where ξ^{cr} denote nominal shares of expenditures. The sourcing coefficients are then given by $\zeta^{cr} \tilde{a}^r = \tilde{a}^r \xi^{cr} = a^{cr}$. The demand pattern is given by $\beta^{cr} = p^c x^{cr} a^{cr} / (\sum_{s=1}^2 p^s x^{sr} a^{sr} + v^r)$. Demand in country c for additional investment generated out of retained earnings is then given by

$$\begin{aligned} \begin{pmatrix} j^1 \\ j^2 \end{pmatrix} &= \begin{pmatrix} \frac{\sum_{r=1}^2 \beta^{1r} \nu^{r1} \left((1 - \sum_t \lambda^{t1}) (m^1 x^{1c}) \right)}{(p^1 x^{1c})} & \frac{\sum_{r=1}^2 \beta^{1r} \nu^{r2} \left((1 - \sum_t \lambda^{t2}) (m^2 x^{2c}) \right)}{(p^1 x^{1c})} \\ \frac{\sum_{r=1}^2 \beta^{2r} \nu^{r1} \left((1 - \sum_t \lambda^{t1}) (m^1 x^{1c}) \right)}{(p^2 x^{2c})} & \frac{\sum_{r=1}^2 \beta^{2r} \nu^{r2} \left((1 - \sum_t \lambda^{t2}) (m^2 x^{2c}) \right)}{(p^2 x^{2c})} \end{pmatrix} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix} \\ &= \begin{pmatrix} d_j^{11} & d_j^{12} \\ d_j^{21} & d_j^{22} \end{pmatrix} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix}. \end{aligned}$$

We denote the elements of this matrix by d_j^{cr} .

SECOND CASE: In this case the investor applies the sourcing structure in the source country (i.e. a foreign investor might continue to rely on the suppliers he is used to). This would lead to a sourcing structure of investments in the FDI receiving country which will reflect the sourcing structure of both foreign investors and domestic producers with weights defined by their relative shares in capacities. We shall not explore this further in any detail here.

Total demand is the sum of the three components: intermediate inputs, additional investment demand (out of retained earnings) and consumption demand.

⁶Here only countries with $m^t > 0$ are included. Countries in which $m^t \leq 0$ are not attracting any additional outside investments and we set $\nu^{st} = 0$. We have specified the simulations of the model reported below in such a way that negative profitability does not arise and hence any negative net investments are excluded.

2.6 Output dynamics: Capacity growth versus demand growth

2.6.1 Capacity growth

For the dynamics of output we assume that supply adjusts to demand. As in classical input-output models for any level of final demand the necessary output can be produced. Final demand is given by the vectors $\begin{pmatrix} f^1 \\ f^2 \end{pmatrix}$ and $\begin{pmatrix} j^1 \\ j^2 \end{pmatrix}$. It can be shown that, given these two demand vectors, total supply satisfying demand will be given by

$$\begin{pmatrix} q^1 \\ q^2 \end{pmatrix} = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} a^{11} & a^{12} \\ a^{21} & a^{22} \end{pmatrix} \right]^{-1} \left[\begin{pmatrix} j^1 \\ j^2 \end{pmatrix} + \begin{pmatrix} f^1 \\ f^2 \end{pmatrix} \right]$$

where the term in the first bracket on the rhs is the Leontief inverse $(\mathbf{I} - \mathbf{A})^{-1}$. As the demand components j^c and f^c are themselves dependent on the output levels of both countries, one has to show that a unique solution for this system exists (see appendix B).

Investment raises capacities and thus enables the economies to grow. As mentioned above, the sum of nominal investment in country r in its own currency is given by $\sum_{s=1}^2 \nu^{rs} ((1 - \sum_t \lambda^{ts})(m^s x^{sr})) q^s$. This (nominal) sum is allocated to purchase physical inputs and labour. For momentarily given sourcing and labour input coefficients, the efficient allocation is analogous to a Leontief production function. In appendix A we show that a 'capacity growth rate' can be derived by calculating the technologically required additions to the quantities of physical inputs and labour and dividing these by the existing stocks of inputs and labour, respectively. It can be shown that this capacity growth rate also equals

$$g_{cap}^r = \frac{\sum_{s=1}^2 \nu^{rs} ((1 - \sum_t \lambda^{ts})(m^s x^{sr})) q^s}{\sum_{s=1}^2 (p^s x^{sr} a^{sr} + v^r) q^r} \quad (2.7)$$

i.e. the growth rate can be expressed as the nominal sum of investment in country r relative to the nominal 'stock' of intermediate inputs plus labour costs. The capacity growth rate depends on the volume of retained earnings in both countries, the allocation of investment spending across countries and the leakages which we shall discuss below.

2.6.2 Demand and output growth

Let us now return to the determination of actual output paths. In section 2.5 we have determined the demand components derived from incomes out of wages and out of retained earnings. Further we have derived capacity growth rates in both countries in section 2.6.1. Demand for physical inputs and labour demand will also be rising at this rate. The dynamic equation for the evolution of output can then be written as

$$\begin{pmatrix} \dot{q}^1 \\ \dot{q}^2 \end{pmatrix} = (\mathbf{I} - \mathbf{A})^{-1} \left[\begin{pmatrix} d_j^{11} & d_j^{12} \\ d_j^{21} & d_j^{22} \end{pmatrix} + \begin{pmatrix} d_f^{11} & d_f^{12} \\ d_f^{21} & d_f^{22} \end{pmatrix} \right] \begin{pmatrix} 1 + g_{cap}^1 & 0 \\ 0 & 1 + g_{cap}^2 \end{pmatrix} \begin{pmatrix} q^1 \\ q^2 \end{pmatrix} - \begin{pmatrix} q^1 \\ q^2 \end{pmatrix}.$$

Note that final (consumption and investment) demand grows at rate

$$g_{dem}^c = \frac{\sum_{r=1}^2 (d_j^{cr} + d_f^{cr}) g_{cap}^r q^r}{\sum_{r=1}^2 (d_j^{cr} + d_f^{cr}) q^r} \quad (2.8)$$

which is (in general) different from the capacity growth rate given above. Note that demand equals the capacity growth rate if capacity is growing at equal rates in both countries (see also appendix B). Further, reformulating the output dynamics equation above, output in both countries grows at rates

$$\begin{pmatrix} \dot{q}^1/q^1 \\ \dot{q}^2/q^2 \end{pmatrix} = \begin{pmatrix} 1/q^1 & 0 \\ 0 & 1/q^2 \end{pmatrix} (\mathbf{I} - \mathbf{A})^{-1} \begin{pmatrix} \sum_r (d_j^{1r} + d_f^{1r}) g_{cap}^r q^r \\ \sum_r (d_j^{2r} + d_f^{2r}) g_{cap}^r q^r \end{pmatrix}. \quad (2.9)$$

Here, output growth equals capacity growth only if capacity growth rates are equal across countries and if the structure of output is at the balanced equilibrium growth path.

The three different growth rates coincide only at an equilibrium balanced growth path. This result, and the conditions for it, are shown in appendix B.

2.7 The balance of payments and exchange rate dynamics

Let us now look at the balance of payments from the viewpoint of country 1. In the two-country case, the value of net exports of country 1 in its own currency is

$$\begin{aligned} TB^1 &= (p^1 x^{11} a^{12} q^2 - p^2 x^{21} a^{21} q^1) + \\ &\quad (\mu^{12} v^2 x^{21} q^2 - \mu^{21} v^1 x^{11} q^1) + \\ &\quad \beta^{12} \sum_{r=1,2} \nu^{2r} \left((1 - \sum_t \lambda^{tr}) (m^r x^{r1}) \right) q^r - \beta^{21} \sum_{r=1,2} \nu^{1r} \left((1 - \sum_t \lambda^{tr}) (m^r x^{r1}) \right) q^r \end{aligned}$$

where TB^c denotes trade balance (which in this special case equals the current accounts). Second, the (net) foreign direct investment inflow (in value terms) in country 1 (again in its own currency) is given by

$$FDI^1 = \nu^{12} \left((1 - \sum_t \lambda^{t2}) (m^2 x^{21}) \right) q^2 - \nu^{21} \left((1 - \sum_t \lambda^{t1}) (m^1 x^{11}) \right) q^1.$$

Third, (net) investment inflows in financial (not capacity-enhancing) assets are given by

$$FA^1 = \lambda^{12} (m^2 x^{21}) q^2 - \lambda^{21} (m^1 x^{11}) q^1.$$

The sum of these three components gives the cash account of country 1

$$CA^1 = TB^1 + FDI^1 + FA^1.$$

A negative balance means a net decrease in official monetary reserves of country c . For the other country the cash account expressed in the currency of country 1 is given by $CA^2 = -CA^1$.

Exchange rate dynamics is modelled in the following way: Adding up all the credit (i.e. value of exports, value of foreign direct investment inflows and net additions to financial assets) and debit components of the three external accounts (i.e. TB^c , FDI^c , FA^c) one can calculate the exchange rate at which the balance of payments would be in equilibrium. We denote this exchange rate by $x^{12,*}$ or $x^{21,*}$ respectively. Exchange rate movements are then determined by

$$x^{cr} = \delta_{x^{cr}} (x^{cr} - x^{cr,*})$$

i.e. the exchange rate adjusts to the equilibrium exchange rate over time.

3 The effective demand problem in the aggregated world economy

>From the growth rate of capacity (2.7) one can see that leakage ($\lambda^{rs} > 0$) always leads to less capacity growth and hence to lower effective demand and lower output growth in the global economy, see equations (2.8) and (2.9). But leakage in one country also has negative (i.e. growth-diminishing) effects on the other country as, first, there is less potential foreign direct investment in the other country and, second, there is less effective demand in both economies. The quantitative size of these effects depends both on the extent of international integration (e.g. expressed by trade and FDI shares) and on the relative size of the two economies.

In this section we briefly discuss the effects of leakage for the aggregated world economy (hence we can omit the country superscripts). Let us assume that the labour input coefficient a_l , the wage rate w and the input coefficient a are constant. Further there is a constant mark-up on costs, $\pi > 0$. Equilibrium prices are then given by $p = (1 + \pi)w/(1 - (1 + \pi)a)$. The equation for output dynamics then reduces to

$$\dot{q} = \frac{1}{1 - a} \left(\frac{(1 - \lambda)m}{p} + \frac{wa_l}{p} \right) (1 + g_{cap})q - q.$$

The capacity growth rate is given by

$$g_{cap} = \frac{(1 - \lambda)mq}{(pa + v)q} = (1 - \lambda)\frac{m}{c} = (1 - \lambda)\pi$$

as $m = \pi c$. The demand components can be rewritten as $m/p = \pi/(1 + \pi)$ and $wa_l/p = 1/(1 + \pi) - a$. Inserting above and rearranging gives the output growth rate

$$\frac{\dot{q}}{q} = \frac{1}{1 - a} \left((1 - \lambda)\frac{\pi}{1 + \pi} + \frac{1}{1 + \pi} - a \right) (1 + (1 - \lambda)\pi) - 1.$$

For $\lambda = 0$ output grows at rate π ; for $\pi = 0$ the system is stationary.

The general relationship between leakage, mark-up and growth rate is shown in Figure 3.1.⁷ At relatively low levels of λ a higher mark-up always leads to a higher growth rate. At a value of λ of about 0.35 a higher redistribution towards profits (a higher mark-up rate) has no longer additional positive effects on output growth. For higher values of λ there is negative output growth which becomes worse as there is further redistribution towards profits.

The reason that, at higher rates of leakage, further redistribution towards profits leads to a contraction of demand, is that the fall in real incomes (and hence spending) of workers outweighs the positive effect of an increase in the mark-up rate on the demand for investment. Looking at the formula we can see that at high rates of leakage the additional demand for investment is smaller than the loss incurred from falling workers demand. It also emerges that the higher a the lower would be the critical value of λ . This means that

⁷The figure was drawn for $a = 0.5$. Other values do not change the graph qualitatively.

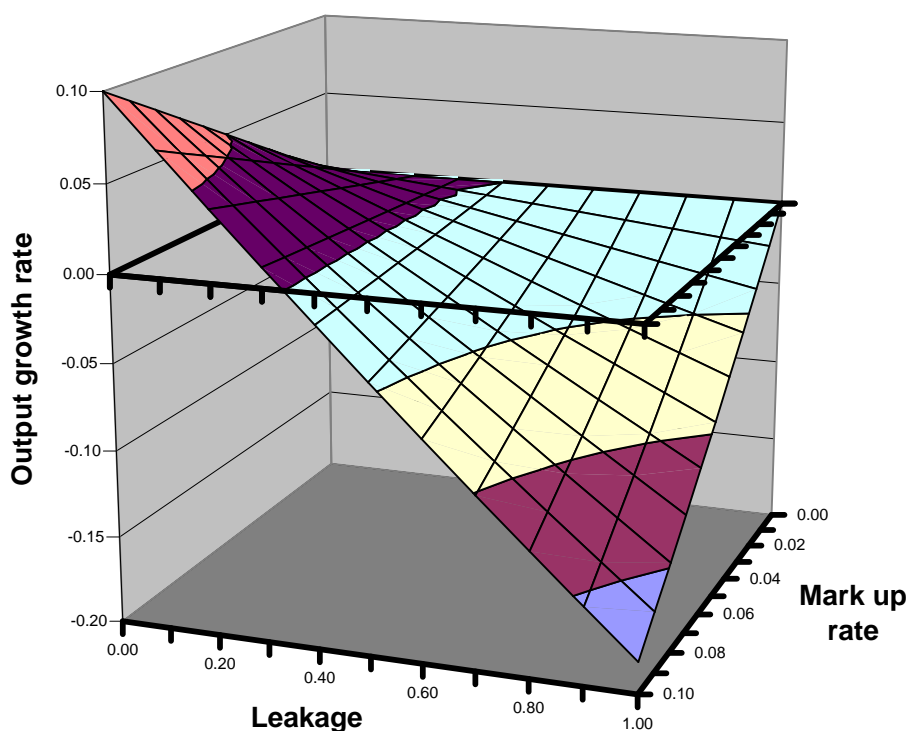


Figure 3.1: The relationship between leakage, mark up rate and growth rate

when there is a higher share of intermediate inputs in total costs one reaches the value at which redistribution towards profits generates negative output growth earlier. This would be the case in more advanced economies (which are characterized by a higher 'degree of roundaboutness').

4 Application 1: A stylized US-EU scenario

We now move to apply the model to a discussion of the two scenarios which were introduced in the introduction: the scenario analysing the impact of the introduction of a new GPT (general purpose technology) upon global economic relations in the context of analysing the relationship between two advanced (sets of) countries: the US and the EU; and the scenario which analyses the impact of successful catching-up processes of a significant group of economies, such as those in South-East Asia, upon global economic relations.

4.1 'Stylized facts'

The first application of the model attempts to discuss the performance of the US versus the EU in the 1980s and the 1990s. Into this period fell Robert Solow's famous remark that 'you can see the computer age everywhere these days, except in the productivity statistics',

which came to be known as the Solow Paradox. However, this remark was made in the 1980s, and in the second half of the 1990s the US experienced a very impressive period of high growth, followed in the early 2000s by a dramatic fall in stock market performance and a slow-down of growth in the advanced economies. In Landesmann and Stehrer (2002) we explained the emergence of the Solow Paradox through an application of the model described above for a closed economy. An effective demand problem could emerge as a result of the redistributive process which the appearance of Schumpeterian rents entails. These emerge particularly in the early phases of the introduction and diffusion of a new GPT (general purpose technology). As part of the emerging rents may be invested into financial assets (or simply lead to an increase in the valuation of existing assets - stock market bubble) the capacity growth rate may be such that actual output falls short of potential output.

In the following simulations we shall explore an international (two-country) setting: Assume that both the US and the EU start at the same technological level and have the same technological potential; however they follow a different time path in the diffusion of new technologies. We shall assume that the US starts earlier to exploit the potential of the new GPT. This means that Schumpeterian rents are emerging first in the US. Due to international linkages (especially trade in intermediate inputs) costs of intermediate inputs in the EU are falling as well and hence also there rents emerge. Furthermore, the differential in unit rents between the US and the EU leads to international foreign investment flows into the US. This situation persists for a while, even after the diffusion process of the GPT has also started in the EU, as the logistic (characterizing the diffusion process of the GPT) begins with a flat stretch and only then gains momentum. The situation is further reinforced through the mechanism which endogenizes the speed of diffusion and makes it (partly) dependent upon the rate of investment (Schumpeterian mechanism) and upon the rate of output growth (Kaldor-Verdoorn mechanism). These two mechanisms allow the US to experience a faster learning-by-doing effect and hence contributes to the differences in productivity growth between the US and Europe in this phase. However, once the US reaches the upper flat part of the logistic (i.e. when the productivity/diffusion potential of the new GPT gets gradually exhausted) the picture reverses. Higher rents emerge in the EU, which implies in turn more attractiveness for international investment, a further impact on an 'endogenous' speeding-up of technology diffusion and productivity growth and an improvement in cost competitiveness. The latter aspect is further complicated through complex dynamics of wage-rent-price effects and the dynamics of exchange rates, which will be further explored in the discussion of the model simulations below.

As mentioned above, the Keynesian aspect of an effective demand problem is brought into the picture through the existence of alternative investment options into liquid assets; alternatively, one can also think of simple asset valuation effects which decouple (paper) returns from real investment processes. We argue that the probability that effective demand problems arise is higher when there are sudden shifts in distributive shares (towards Schumpeterian rents and away from wage incomes) and when there has to be a greater reliance on the investment component (out of 'retained earnings') of effective demand. However, the high attractiveness for foreign investment due to differential rents can coun-

Parameter	US	EU
Technical coefficients		
a^c	0.500	0.500
a_l^c	0.500	0.500
$g_{a_i}^c$	0.050	0.050
g_k^c	15.000	15.000
Price system		
π^c	0.000	0.000
δ_p^c	0.100	0.100
Labour market and wage rates		
κ_s^c	0.050	0.100
κ_u^c	-0.100	-0.050
$\delta_{k,IN}^c$	1.000	1.000
$\delta_{k,OUT}^c$	0.010	0.010
Quantity system		
σ_ζ^c	2.500	2.500
ρ_ζ^{cc}	0.900	0.900
ρ_ζ^{rs}	0.100	0.100
σ_ν^c	2.500	2.500
ρ_ν^{cc}	1.000	1.000
ρ_ν^{rs}	1.000	1.000
σ_μ^c	2.500	2.500
ρ_μ^{cc}	0.900	0.900
ρ_μ^{rs}	0.100	0.100
Exchange rate dynamics		
δ_x^{cr}	-0.100	-0.100
Financial system		
λ^c	0.000	0.000

Table 4.1: Parameter values used in scenario 1

teract such tendencies, and inflict - in turn - a 'leakage' effect on the 'latecomer' in the diffusion process (the EU). The EU benefits in this phase from higher external demand in the US, but loses as a result of a falling-behind in competitiveness and net capital outflows. The loss in competitiveness and attractiveness for international investment can be counteracted by following a strategy of similarly shifting distributive shares in the direction of higher retained earnings (thus reducing the labour share), but this increases the potential for a 'deflationary bias' in the global economy.

4.2 Assumptions

We now briefly discuss the specific assumptions used in the simulation studies discussed below. Table 4.1 shows the parameter values used in the first scenario. Both countries have the same technological potential (i.e. the final level of labour productivity is given

exogenously and is equal for both countries) and the same (exogenous) growth rate of the logistic. Further the parameter capturing the Kaldor-Verdoorn effect is equal across countries. This specification implies that the first user of a new technology has cumulative dynamic advantages in the first phase of the diffusion of a new technology. With regard to the specification of the price system both countries are equal. For simplicity we set the exogenous profit rate $\pi^c = 0$ which implies that the economies are stationary in the long run (i.e. when there are no further technological impulses). Prices adjust relatively slowly to unit costs and there is an even slower tendency that prices equalize across countries over time. There are however differences in labour market parameters. The US has a lower bargaining parameter (of workers over emerging rents) and a higher Phillips-curve parameter than the EU. The parameters for the CES-specifications imply substitution elasticities of 2.5 for all components of demand and for the allocation of retained earnings (being responsive to relative per-unit rents) across countries. Further, at equal prices, 90 per cent of expenditures are spent domestically (home-market bias); rents are distributed only according to differences in per-unit rents (i.e. there is no home-bias).

In the second scenario we introduce leakage in the way that 5 per cent of rents arising in the US are invested in a financial (non-interest-bearing) asset. As already discussed above, this lowers the growth rate of the economy and slows down the process of diffusion of the new technology (via the Kaldor-Verdoorn effect). Note that leakage in the US also slows progress in the EU, as less is demanded, which lowers the growth rate of the EU as well.

In the third scenario we model the effects of labour market liberalization in the EU via a lower bargaining parameter (i.e. $\kappa_s = 0.09$) and, simultaneously, allow for a 'leakage' effect in the EU as well amounting to 5 per cent of EU rents. This scenario shows that, first, the EU gains in competitiveness relative to the US and has generally a better relative performance (compared to the US) than in scenario 2 but that, second, world output and country-specific output (and employment) levels are below the levels in scenario 2.

Before discussing the results of the simulations we present the starting values in Table 4.2. Both countries start from the same position in every respect. The economies are in a long-term stationary state (as profit rates are assumed to be zero) with full employment and balanced current accounts.

4.3 Results

4.3.1 Scenario 1: No leakage

Let us start with a discussion of the first scenario without any leakage. As discussed above, the US is the first beneficiary of the impact of the new GPT and experiences a (positive) productivity shock earlier than the EU. This implies an earlier decline in prices, an earlier rise in the wage rate, higher per-unit rents and hence a stimulus to investments and output. As one can see in Figure 4.2 there is also a difference in levels with the laggard never reaching the same level of Schumpeterian rents per unit. This is in line with the Schumpeterian argument that the laggard has to deal with the price-to-cost pressure from earlier innovations. The same can be found for some of the other

Variable		Values
a_l^c	Labour input coefficient	1.000
w^c	Wage rate	1.000
v^c	Unit labour costs	1.000
p^c	Price	2.000
c^c	Costs	2.000
r^c	Profits	0.000
s^c	Rents	0.000
j^c	Investment demand	0.000
f^c	Consumption demand	0.500
q^c	Output	1.000
l^c	Labour demand	1.000
k^c	Labour supply	1.000
u^c	Unemployment rate	0.000
γ_q^c	Growth rate	0.000
x^c	Exchange rate	1.000
TB^c, FDI^c, FA^c, CA^c	BoP components	0.000

Table 4.2: Starting values used in simulations

variables such as the accumulation rate and output (the underlying mechanism here is that the cumulative endogenous productivity effects arising earlier in the US give the US the advantage of a lasting real depreciation and hence of a long-run shift in real market shares). Hence there is a lasting penalty for not being the innovator! In terms of external economic relations, the initial differential boost to demand in the US market means that export rates (exports/production) fall in the US and rise in the EU, as the US market is expanding faster. Import rates (imports/production) fall in the US and rise in the EU as US producers are more competitive and they gain market shares in both markets. On the trade balance (exports-imports; CA) it turns out that the income effects are stronger than the substitution effects as the US trade balance turns initially negative and the EU balance positive; this means the relative market growth effect initially outweighs the change in competitiveness. After the initial period, however, the trade balances start to reverse, as the EU (with the delayed logistic) catches up in competitiveness and this provides a stimulus to its relative growth. Looking at capital (net FDI) flows (driven by relative unit rents) it is clear that up to period 8, the US is attracting net capital flows as it is more profitable to invest there, after which the productivity growth rates of the laggard economy (the EU) start to outstrip those of the US and relative profitability starts to be in favour of the EU.

Exchange rates are driven by changes in the trade balances, with the US depreciating its currency initially and the EU appreciating its currency. After period 8 the deficit in the US trade balance declines, but it takes until period 10 when the currency starts to appreciate. As the determinants of the trade balance and the capital accounts balance are somewhat independent of each other, there is no reason for the sum of the two to balance and hence we see a fall in reserves in the US (as its trade deficit is greater than its

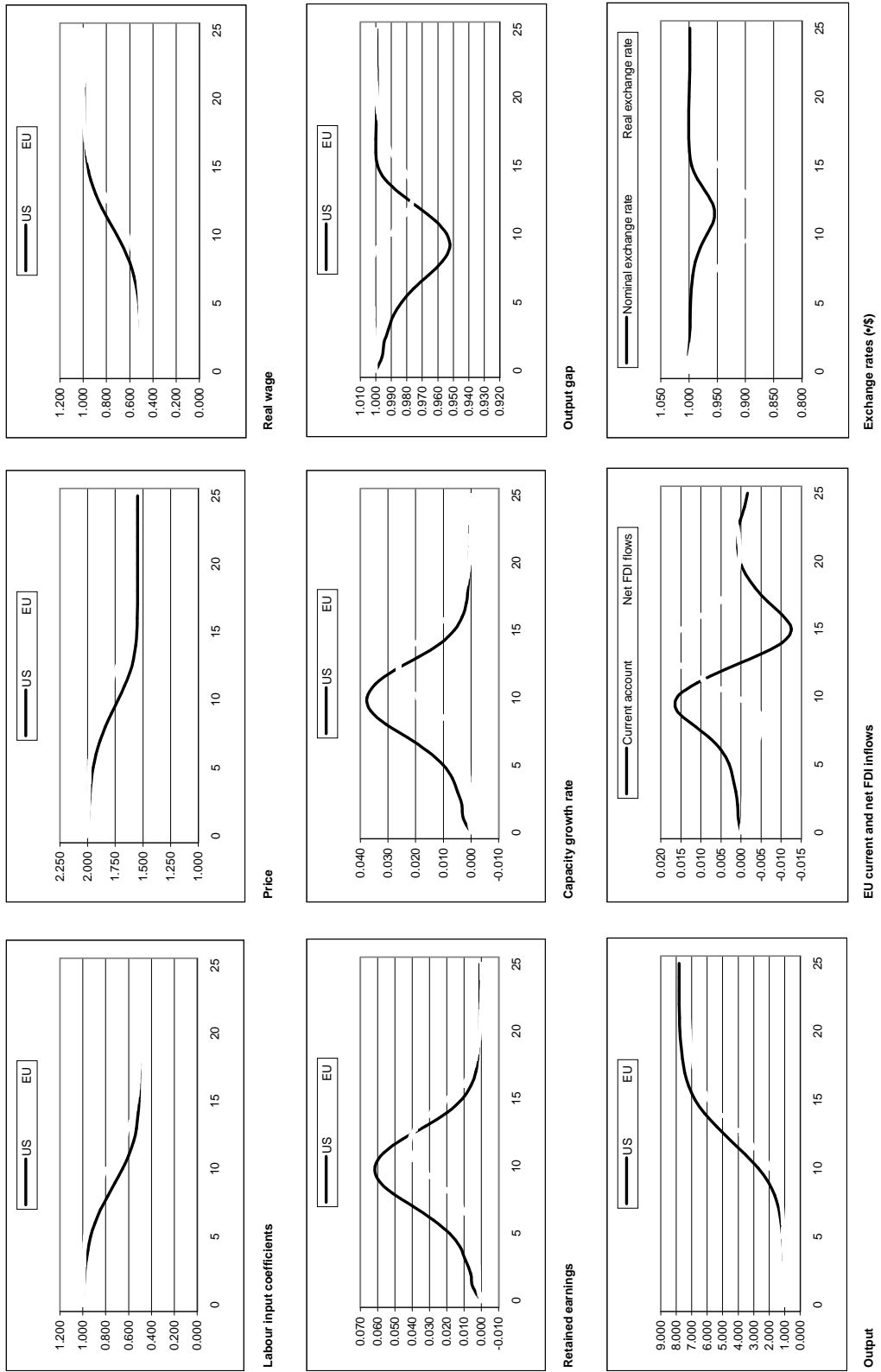


Figure 4.2: Scenario 1 (without leakage)

capital inflows) and a rise in reserves in the EU. This, as mentioned above, turns around in period 10, when there is a turnover between the two regions in the relative sizes of trade and capital flow balances. Net capital flows already start to move in favour of the EU from period 8.

As regards the measure of 'utilization of the productive potential' (actual output/potential output) this is a function of two variables: the evolution of capacity (closely linked to retained earnings) and the evolution of output (as determined by the levels of demand). Here we can see a short period in which the US has a lower utilization rate than the EU as its productivity levels - and hence unit rents - improve strongly (initial phase of the logistic) and this is in spite of its actual output growth being higher than in the EU. Hence, in this period, the US experiences a stronger increase in its productive potential than in its demand. From period 6-7, the US utilization rate improves, due to a slow-down in the rate of productivity growth (and growth in capacity) and still growing and higher levels of demand in its home market, as well as a peak level of its relative competitiveness. The relative competitiveness declines only gradually (as it is a function of relative cost levels rather than rates of change) and hence the US utilization rate is profiting from sharply improving trade balance positions which give a boost to its effective demand. This is the period in which the EU utilization rate is at its worst, as its level of competitiveness is still low and it undergoes a period of rapid productivity growth, a shift towards retained earnings, thus financing capacity growth and hence a growth in productive potential.

4.3.2 Scenario 2: Leakage in the US

In scenario 2 US rent earners invest part of rents into a (non-interest-bearing) financial asset; we assume that it amounts to five per cent of the rents over the whole period. We assume that these rents are just dissipated (true 'leakage') in that they are neither used for consumption nor lead to additional investment into real assets in later periods. These issues have been explored in an earlier paper (Landesmann and Stehrer, 2002) where we did allow for the accumulation of real and (interest-bearing) financial assets, and where the latter could be used later on to finance real investments or repay an initial debt which arose from the pre-financing of investment by the banking sector. We could show in this paper that there are real output effects arising from such accumulation and decumulation of financial assets and hence the more simplified framework adopted in this paper could be generalized to account for a more complex relationship between the real and financial sector, while yielding similar qualitative results.

The simple assumption made in this paper with respect to 'leakage' leads naturally to negative long-run effects on output and employment levels as the proportion of rents invested in the financial asset does not translate into additional demand for productive capacities (investment goods and labour). In the simulation shown (Figure 4.3 shows the differences between scenarios 2 and 1) the leakage effect amounts to lower levels of output of about 20% towards the end of the simulation period (hence the output level effect is not transitory). We can also see that all the output growth difference resulting from the leakage takes place in the first half of the simulation runs, as it is in this period

that most of the Schumpeterian rents accrue. In addition, leakage also affects endogenous productivity growth (see the diagram with the labour input coefficients) as differences in investment rates also affect the speed by which an economy moves along the logistic which in turn determines levels of labour productivity.

Compared to the no-leakage situation, US producers suffer for two reasons: in the no-leakage situation they benefited from higher domestic demand and the higher endogenous productivity effects. The latter translated into higher capacity growth effects and higher consumption demand derived from higher real wage growth. Given the lower level of domestic demand in the current scenario, however, the current account situation of the US improves in the first phase of the leakage scenario and there is less pressure on real depreciation. The EU suffers as well in the US-leakage scenario mainly because of less export demand, lower output levels and a lower growth rate of labour productivity. Also in the period when the EU catches up in productivity terms, there are less gains to be made by EU producers, as less US rents get invested and hence - although EU relative unit rents improve - there will be less FDI flows to the EU. On the competitiveness side, we already mentioned that the lower demand growth in the US leads to less pressure on the US current accounts and hence to less depreciation of the US currency which makes the EU producers relatively less competitive in the early phase compared to the no-leakage scenario. We can also see that the domestic price level of US producers falls more in the leakage scenario given the low bargaining strength of US workers and the stronger Phillips curve effect. This is also the cause of the even stronger longer-run real depreciation effect of the US currency in the US-leakage scenario.

4.3.3 Scenario 3: EU responses (EU leakage and labour market changes)

In the previous scenario we have seen that, given the labour market characteristics in the US and the EU introduced into the model, the low demand (leakage) scenario in the US goes along with relatively strong wage effects in the US and a stronger real exchange rate depreciation in the long run. This amounts to pressures on the EU's competitiveness. A possible response are changes in EU labour market characteristics.

We introduce these in the form of a change in the bargaining parameter of EU workers over rents (we reduce it to a value of 0.09) which, of course, also means a higher share of retained earnings and a shift in the EU towards the investment component of effective demand. Secondly, we allow also in the EU for 'leakage' behaviour in that a certain proportion of rents gets invested into a (non-interest bearing) liquid asset; we can imagine this as the costs of some degree of capital market liberalization which lead to some resources being diverted into covering financial market transactions costs. The result of these changes (see Figure 4.4) is - as expected - a higher redistribution towards retained earnings (i.e. profits) in the EU. This gives rise to higher capacity growth effects which are financed out of these increased profits. On the other hand, there are reduced real wage levels and, given the leakage effects (see also the analytical discussion in section 2.6), the overall demand effects are negative. Output growth suffers particularly over the main period of redistribution. On the other hand the EU - thanks to this redistribution - manages more capacity growth in this period.

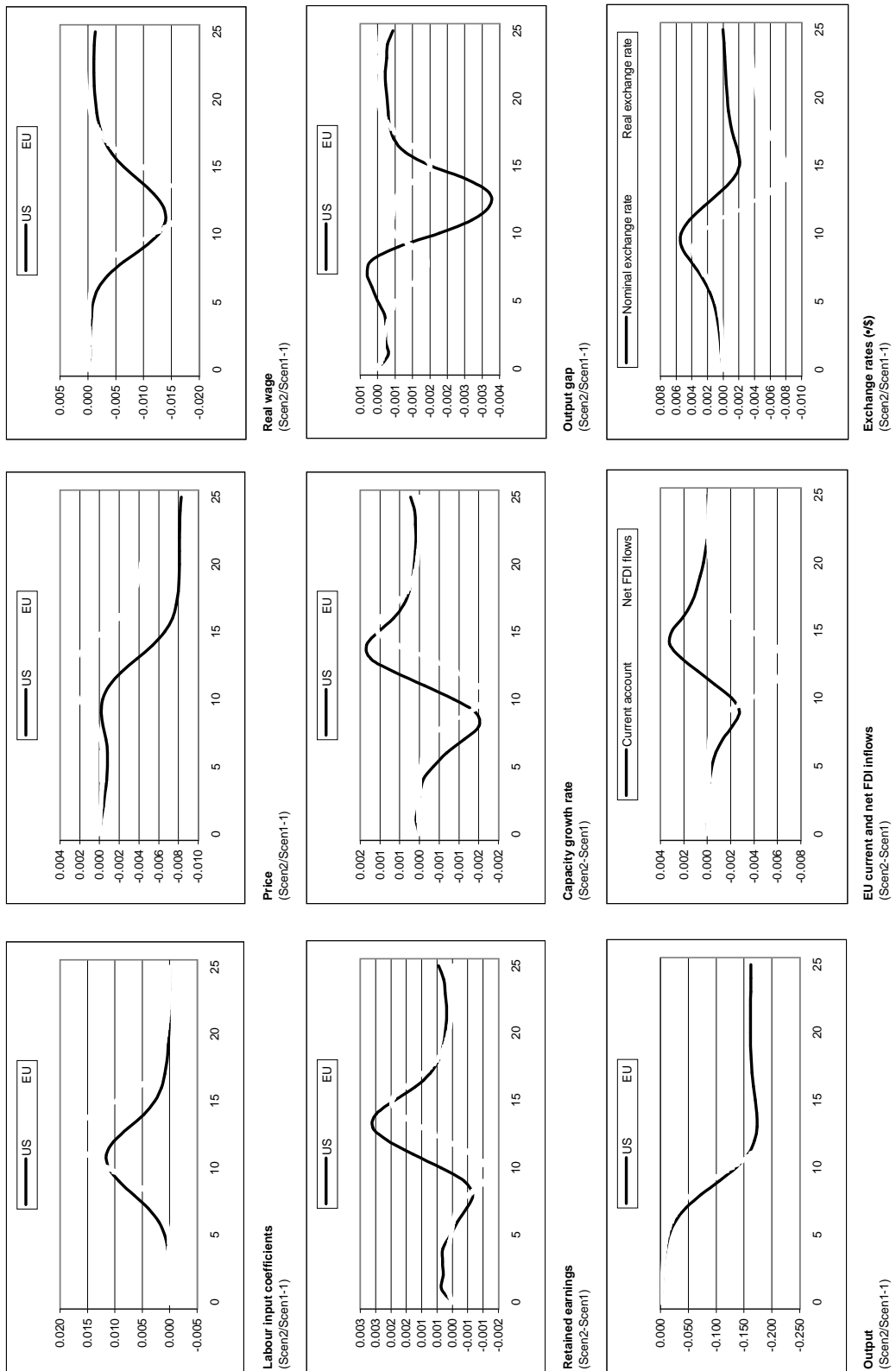


Figure 4.3: Differences between scenarios 2 (leakage in US) and 1

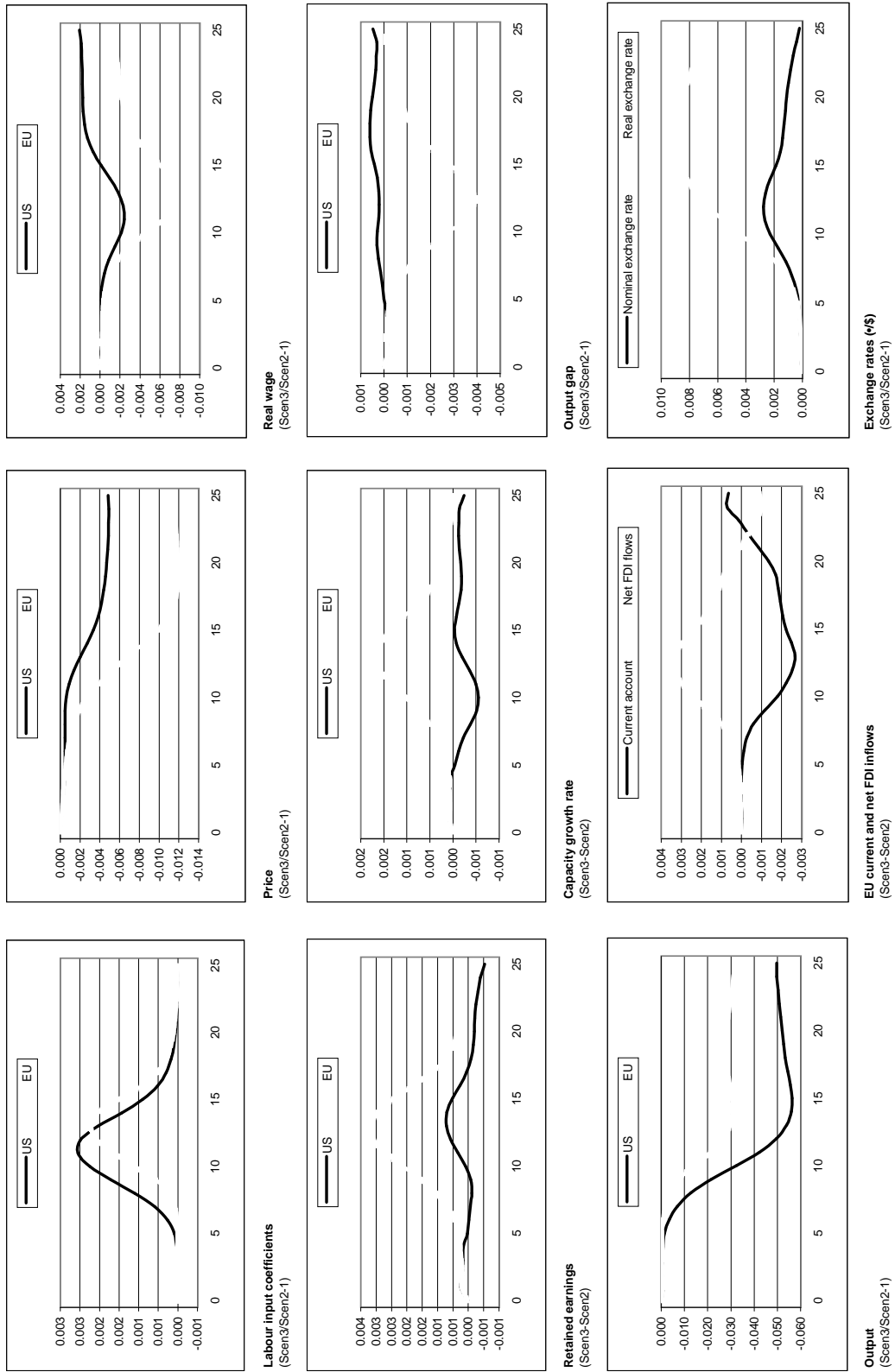


Figure 4.4: Differences between scenario 3 (leakage in US and EU and EU labour market adjustments) and 2

The EU is first losing and then gaining in scenario 3 in its current account. The reason is that - compared to scenario 2 which introduced a leakage effect only in the US - the US suffers more in output loss than the EU as EU import demand declines more than US import demand. The EU is furthermore improving very much in terms of FDI inflows as its relative profitability has gained from the higher 'flexibility' of its labour market. There is also a strong impact on the real exchange rate compared to scenario 2: the EU is relatively depreciating as the stronger wage restraint is leading to a much sharper fall in the domestic producer price level; hence this scenario demonstrates the gains made by EU producers in competitiveness; this is in spite of the loss made in terms of endogenous productivity growth, as the wage effect outstrips the productivity effect on unit costs.

Finally, let us discuss the contributions of the two economies to the global output gap. Already in the comparison of scenarios 1 and 2 we could see that an economy suffers from the leakage behaviour of its trading partner. Something similar is now happening in scenario 3 compared to scenario 2: The US is suffering from the EU's additional leakages and initially the EU as well. But from a certain point onwards (periods 12-13) the EU is doing better in terms of the output gap as it benefits in terms of long-run competitiveness due to wage restraint which has a current account and an FDI inflow effect. This makes the point that there are incentives for an economy to move towards labour market flexibility, particularly for highly open economies.

5 Application 2: A stylized catching-up scenario

5.1 'Stylized facts'

In this section of the paper, we shall address the other important event in global economic relations over the post-war period: the successful catching-up processes of a group of developing, particularly East-Asian, economies. The catching-up process of these economies was very much characterized by high rates of productivity growth (following the logistic pattern used in the present model), by high investment ratios, by a high level of attraction for FDI and by a secular tendency of real exchange rate appreciation. We shall discuss in the following model simulations the combination of these features which characterized the processes of catching-up of these economies. We shall also analyse what they meant for global economic relations, in particular the reaction mechanisms induced in the advanced economies and the issue which concerned us in this paper, i.e. potential effective demand failures at the global level.

5.2 Results

5.2.1 Scenario 4: The impact of catching-up on global economic growth

The scenario we present is set up in such a way that we can compare the difference which the catching-up process of a (significant) group of catching-up economies makes, as compared to the scenario depicted above, where there was simply a lag in the application of a new GPT between one advanced economy (or set of economies) - the EU - and

another advanced economy - the US. The specific parameters are the same as in scenario 1 above with the exception that we set $\kappa_u^c = -0.075$ and $\kappa_s^c = 0.075$. The main difference we introduce is however that we start off with a substantial 'gap' in initial productivity levels between the advanced group of economies (the ACs) and the catching-up group (the CUs). We shall take scenario 4 (see Figure 5.5) as a base simulation and look at a situation in which there is a successful catching-up process of CUs following a logistic pattern as well. This scenario introduces - what we call - a 'Gerschenkron effect', i.e. catching-up economies have the advantage of being able to exploit the technological potential developed initially by the advanced economies (Gerschenkron, 1952, 1962). In terms of the model structure, we assume that the CUs start from lower productivity levels (i.e. with higher labour input coefficients) than the ACs and then approach - following a logistic path - in the long run the productivity levels of the ACs. We can see that in Figure 5.5 (as compared to e.g. Figure 4.2 of scenario 1) there is an additional boost to productivity levels of the CUs as compared to the US-EU scenario discussed above. This additional boost in productivity levels generates a further fall in price levels (particularly in the CUs), an additional boost to real wages, an additional big boost to retained earnings in the CUs and hence an expansion of capacity (further complemented by FDI inflows); and an additional boost on output levels as both the ACs and CUs benefit from the growth-enhancing effects derived from higher real incomes and higher global spending on investment and consumption goods. Given the additional boost to the CUs per unit retained earnings, the capital account balance of the CUs becomes more positive (negative for the ACs), and - as before - the real income growth effect outstrips the substitution effect to lead to a further negative trade balance of the CUs. Over time, as before, the productivity catching-up process (the Gerschenkron effect) peters out; Schumpeterian rents dwindle away (through price-to-cost adjustments and wage claims) and the trade and capital flow accounts move back into balance, although there seems to be a long-run effect between the two, due to a long-run relative price adjustment which drives the real exchange rate.

Hence, summarizing the difference between the US-EU scenario and the catching-up (AC-CU) scenario, we can say that the Gerschenkron effect adds a stimulating impact upon global demand and output, leads to further redistribution of FDI resources towards the lagging (but high rent) economy and can lead to an adjustment in long-run relative price levels (measured in the same international currency). We shall now explore the sensitivity of these results to changing certain key parameters of the model.

5.2.2 Scenarios 5-7: Sensitivity analysis of the catching-up scenario

In this section we summarize the results obtained from exploring the sensitivity of the catching-up scenarios in relation to changing particular features which characterize the labour market and spending behaviour in the advanced and the catching-up economies. As the structure of the model is now quite familiar, it is easy to forecast the impact of such changes upon the dynamic paths generated by the model: We already know (both from the theoretical analysis and from the earlier set of simulations) that a weakening of the bargaining power of the workers (over rents) has - *ceteris paribus* - a stimulating effect

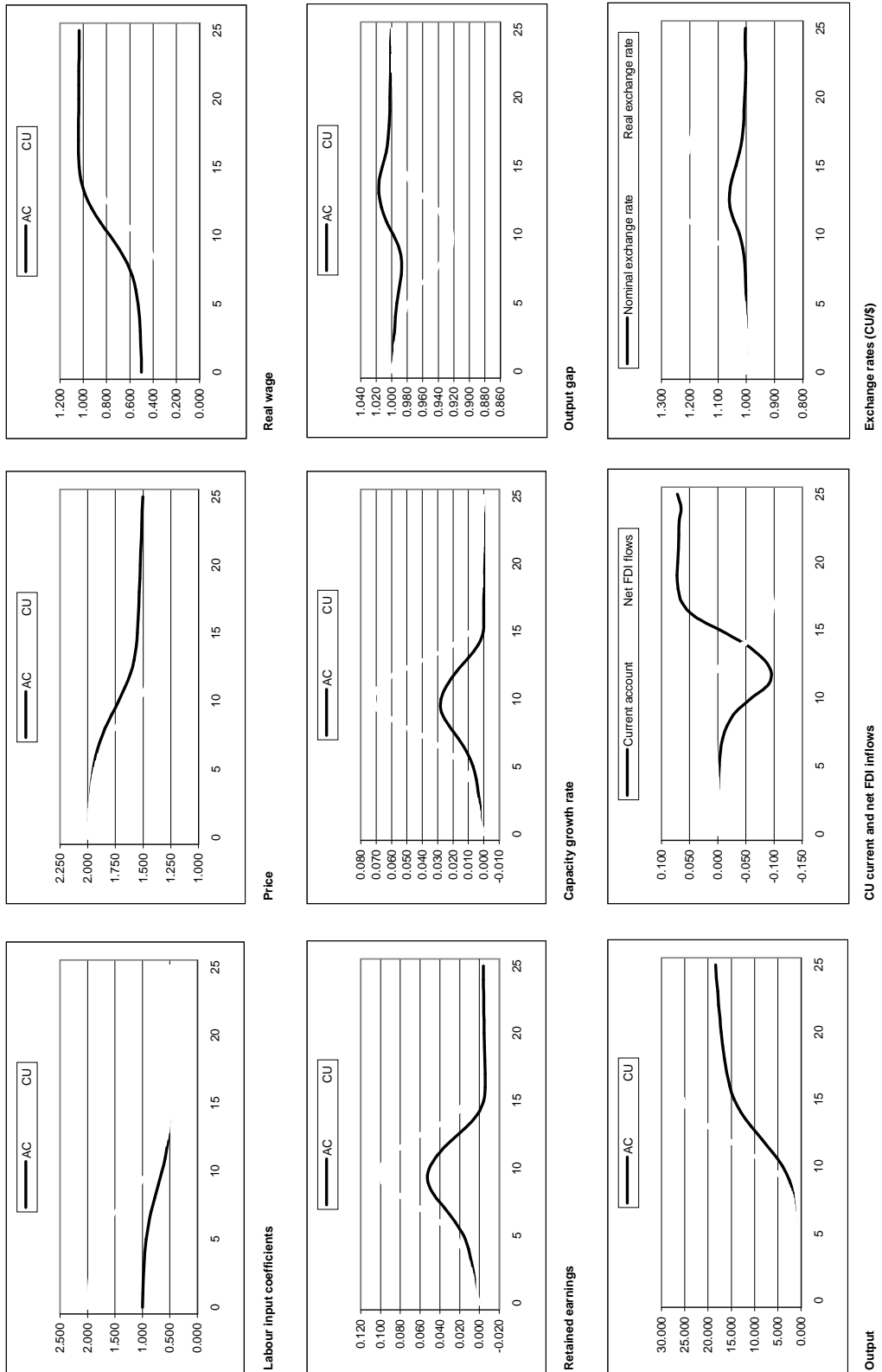


Figure 5.5: Catching up scenario

on growth as long as the leakage behaviour out of retained earnings is not too high. Once the threshold has been reached, a further decline of the distributive shares of workers has a depressing effect on output growth. In an application to catching-up economies we can think of such 'leakage' as being the result of rent-seeking processes (siphoning-off of rents to support a relatively inefficient bureaucracy, or the leakage of retained earnings into foreign bank accounts, etc.). If that type of behaviour is very characteristic of a (potentially) catching-up economy, the catching-up process itself gets impeded, as the speeding-up of technology transfer (speed by which there is a move along the logistic) does not take place and, missing out on these endogenous productivity effects, less FDI is attracted, etc.

On the other hand, one can experiment with parameters which would characterize the reaction by advanced economies to the competitive challenge by CUs. Here again the impact on two types of ACs are interesting: ACs which are characterized by a higher bargaining power of workers (and less effect of unemployment upon the wage bargaining mechanism) - the stylized image of the EU - and ACs which are characterized by very weak bargaining power of workers and a high impact of unemployment upon the wage bargaining mechanism - the stylized image of the US. The simulations show, as expected, that, given the competitive challenge of CUs, the ACs would benefit from a general liberalization of labour markets (i.e. moving towards the US model rather than the EU model): liberalization of labour markets means that (per unit) retained earnings can be higher, which implies more attractiveness to international capital movements. This benefits the relative (endogenous) productivity dynamics of ACs versus CUs and improves relative price competitiveness. Within the structure of the model, the trade-off with effective demand problems at the global (and national) level depends again on whether or not a certain threshold level of 'leakage' behaviour out of retained profits has been reached: below that level, a weakening of workers in labour markets benefits global demand, above it, it can generate effective demand problems at the global (and national) level, depressing global growth.

6 Conclusions

Let us first summarize the main points of the analysis conducted in this paper and derive some policy conclusions. The paper has attempted to point to a type of coordination problem which emerges in a globalized economy when nobody wants to feel responsible for the overall level of 'effective demand' while the incentive structure moves strongly in the direction of cost competitiveness and relative profitability advantages. We know this coordination problem from the literature on the micro-foundations of macro-economics (see e.g. Cooper, 1999) where individual firms consider the impact of cost positions and pricing on their market share positions but not on the location of the overall demand curve. The situation in the global economy is analogous: a small economy in a global context has to consider its market share position rather than the location of the global

demand curve.⁸ In our model, there are two types of market shares: one in overall sales, the other in the amount of international capital an economy attracts. The market shares in sales depend upon cost and price competitiveness, the market shares in international capital flows depend upon relative profitability. We can see that in terms of the different countries' positions in these two types of markets, the determinants of cost/price competitiveness and of profitability are important. These determinants are partly coinciding (such as relative productivity and wage growth), but they are also partly going in opposite directions: e.g. a fast price-to-cost adjustment is good for price competitiveness in the short run, but is bad for profitability; in the longer run there is more coincidence, as higher profitability leads to more investment, hence faster endogenous productivity growth and hence improvements in cost competitiveness. Take another example, the exchange rate: A depreciation of the exchange rate is *ceteris paribus* good for cost/price competitiveness of an economy in the short run; but it has a negative effect on comparative per unit profits as profitability has to be compared - as do costs and prices - in an international currency. Lower comparative profitability means less attractiveness for international investment flows and - given the endogenous productivity growth effects of such investments - also lower cost competitiveness in the longer run.

>From the above we can see that the workings of the labour and product markets (which define the wage-productivity and hence cost dynamics on the one hand, and the price-to-cost dynamics which determines price and profitability paths on the other hand) in different regions determine the relative position of different economies in the global (product and capital) markets. They also determine, as externalities, the overall effective demand situation in the global economy!

We have applied the model to two types of situations which have characterized developments in the global economy over the past 15-25 years: First, we analysed the diffusion process of a new general purpose technology (information technology) and we analysed the case in which one economy - the US - is a forerunner in the innovation and diffusion process of that technology and another economy - the EU - is a laggard in this respect. This leads to an interesting dynamic in which Schumpeterian rents emerge and the international investment dynamic is driven by an interplay between the speed of technological change in the leading and lagging economies and distributional conflicts over the emerging rents. These factors also determine the evolution of cost- and price competitiveness, and consequently the dynamic in trade balances and in nominal and real exchange rates. We have shown that different behaviour on labour markets and in spending out of retained earnings affect the investment and output dynamics of the two economies and the relationship between capacity build-up and levels of effective demand.

Next we dealt with the application of the model to the analysis of another phenomenon which characterized recent international economic history: the experience of a significant group of previously low-income economies catching up with the advanced economies in productivity terms in a rather spectacular manner. Also in this case, we are dealing with the interaction of two significant (groups of) economies, an advanced group and a group

⁸In the case of economies of significant size in the global economy, the argument still carries through in terms of the neglect of the externality effect of individual countries' behaviour on global demand.

which lags behind in the introduction of new technologies, with the difference that there is also a significant technology or productivity gap at the starting point. A proper analysis of this interaction requires a full paper in itself, but we shall focus here on but a few aspects which demonstrate that catching-up processes of a significant group of catching-up economies imply, firstly, significant adjustment pressures on the advanced economies and, secondly, might generate additional problems in relation to maintaining a sufficient level of effective demand in the global economy (see discussion above).

The initial technological gap provides the basis for an additional Gerschenkron effect ('advantage of backwardness'), i.e. it creates a potential for fast productivity growth which was not present in the previous analysis of the US-EU interaction (both of these countries were assumed to start from the same level of productivity, but then one of them - the US - introduced a new GPT earlier than the other group of advanced economies). The high potential for productivity growth, when it is exploited, means that in the catching-up economies, the potential for cost reductions and the scope for (transitory) per-unit rents will be particularly high. This implies that these economies will have the scope to be highly competitive in both respects: improving price competitiveness on product markets and a high attractiveness for FDI. Fast productivity growth, leading to high real wage growth and/or a high volume of retained earnings will foster fast output growth and a high accumulation rate, thus leading to additional endogenous productivity growth. The competitive challenge for the technology leader (i.e. the advanced economies) is in this case more formidable than in the case described earlier in the relationship between the US and the EU. The reason is the additional Gerschenkron effect. On the other hand, there is a boost of potential demand generated from a new fast growing region with an increasing weight in the global economy.

Let us now come to the global 'effective demand' issue: there are good reasons to believe that the income distributional shifts (towards retained earnings) in the case of successful catching-up economies are higher than in the US-EU case. Firstly, these economies undergo faster productivity growth and hence - given the same behavioural parameters in wage bargaining and product market characteristics - there will be higher relative unit rents. Secondly, one can assume that the wage bargaining parameter will be weaker for a number of reasons: the lower degree of organization of workers in less developed economies, the possible availability of a higher reserve army of labour (Lewis' model of 'unlimited supplies of labour', Lewis (1954)) and, at times, authoritarian state structures. The implication is that in successful catching-up economies the scope for high (per unit) retained earnings can be very high in the process of catching-up. This can lead to a strong build-up of production capacities, further fuelled by the relative attractiveness to FDI.

In a context in which the weight of the catching-up countries is increasing in the world economy, the response mechanism of the advanced economies to this double competitive challenge (on product markets with the catching-up countries' strong cost competitiveness and on capital markets with strong FDI attractiveness) will be to shift towards a strategy which attempts to compete in unit costs and (per unit) retained earnings: high retained earnings support the endogenous productivity growth mechanism (shifting the technology frontier) and allow advanced economies to regain competitiveness on capital markets, and a low wage-to-productivity dynamics (i.e. a weakened bargaining position of workers)

improves cost competitiveness. The effect is an accentuation of the 'deflationary bias' at the global level which we have already emphasized in the analysis of the interaction between the US and the EU in the wake of the diffusion process of a new GPT in the main part of this paper.

A Calculation of capacity growth rate

As we have a model with variable capital only, we use the ratio of investment to the 'stock' of intermediate inputs as a proxy for the growth rate of capacity.⁹ The stock of intermediate inputs for a particular country r consists of the stock purchased domestically or abroad and for given coefficients a^{sr} this is given by $\sum_s a^{sr} q^r = \tilde{a}^r q^r, s = 1, 2$. The (nominal) investment spending has to be allocated across purchases of intermediate inputs and labour inputs. For technical coefficients, prices, wage rates and the exchange rate fixed the nominal sum spent for capacity increases in physical inputs is given by

$$\frac{(p^s x^{sb}) a^{sr}}{\sum_{s=1}^2 (p^s x^{sb}) a^{sr} + (v^r x^{rb})} \frac{\sum_{s=1}^2 \nu^{rs} (1 - \sum_t \lambda^{ts}) (m^s x^{sb}) q^s}{(p^s x^{sb})}$$

and

$$\frac{(w^r x^{rb}) a_l^r}{\sum_{s=1}^2 (p^s x^{sb}) a^{sr} + (v^r x^{rb})} \frac{\sum_{s=1}^2 \nu^{rs} (1 - \sum_t \lambda^{ts}) (m^s x^{sb}) q^s}{(w^r x^{rb})}$$

is spent for additional labour inputs. Dividing this expression by the 'stock' of intermediate inputs of this component $a^{sr} q^r$ or the 'stock' of labour $a_l^r q^r$ (expressed at current prices, exchange rates and wage rates) we get the physical rate of capacity growth in country r as given in equation (2.7).

B Equilibrium solutions

B.1 Existence

For constant technical coefficients the price system can be written as

$$\mathbf{p}^\top \mathbf{X}^b = (\mathbf{p}^\top \mathbf{X}^b \mathbf{A} + \mathbf{v}^\top \mathbf{X}^b) (\mathbf{I} + \mathbf{\Pi})$$

where \mathbf{X}^b denotes a diagonal matrix including the exchange rates (i.e. expressed in currency of country b). Rearranging gives the equilibrium price vector

$$\mathbf{p}^\top \mathbf{X}^b = \mathbf{v}^\top \mathbf{X}^b (\mathbf{I} + \mathbf{\Pi}) [\mathbf{I} - \mathbf{A} (\mathbf{I} + \mathbf{\Pi})]^{-1}.$$

Nominal wage rates are stable if $s^c = 0$ or $u^c = 0$. The first condition is given by inserting equilibrium prices into the definition of rents:

$$\begin{aligned} \mathbf{s}^\top \mathbf{X}^b &= \mathbf{p}^\top \mathbf{X}^b - \mathbf{c}^\top \mathbf{X}^b (\mathbf{I} + \mathbf{\Pi}) = \mathbf{p}^\top \mathbf{X}^b (\mathbf{I} - \mathbf{A} (\mathbf{I} + \mathbf{\Pi})) - \mathbf{v}^\top \mathbf{X}^b (\mathbf{I} + \mathbf{\Pi}) \\ &= \mathbf{v}^\top \mathbf{X}^b (\mathbf{I} + \mathbf{\Pi}) [\mathbf{I} - \mathbf{A} (\mathbf{I} + \mathbf{\Pi})]^{-1} (\mathbf{I} - \mathbf{A} (\mathbf{I} + \mathbf{\Pi})) - \mathbf{v}^\top \mathbf{X}^b (\mathbf{I} + \mathbf{\Pi}). \end{aligned}$$

The second condition of full employment is assured, first, by the labour force dynamics (inflows and outflows) and, second, by the Phillips curve effect. In case of unemployment

⁹It can be shown that in equilibrium this growth rate corresponds to the growth rate of a model with fixed capital.

wages are depressed which allows for rents and (under the assumption of investment of these rents) the economy to grow (above the equilibrium growth rate) which implies higher labour demand and vice versa for excess demand for labour.

As for output, we first show that an equilibrium output vector exists at all. In standard input-output theory it is shown that given any final demand vector the necessary output vector can be calculated using the Leontief inverse (if the input-output matrix satisfies certain conditions). In our case this problem is different as we have the homogenous equation

$$\mathbf{q} = \mathbf{A}\mathbf{q} + \mathbf{j} + \mathbf{f} = \mathbf{A}\mathbf{q} + \mathbf{D}_j\mathbf{q} + \mathbf{D}_f\mathbf{q}.$$

Assuming that all income is spent one can show by premultiplying this equation with the price vector that the rows are linearly dependent; thus a solution exists. Note that this result is derived with any price vector (not necessarily the equilibrium price vector). Thus there exists a non-trivial quantity vector for any allocation of demand out of profit and rent income and wage income which satisfies the equation above. As usual, the structure of output is determined, but not the level.

B.2 Balanced growth path

Let us finally discuss the balanced growth path of the two economies. Here we only discuss conditions for balanced equilibrium growth which do not imply that the BoP is in equilibrium.

FIRST CASE: One gets the classical solution in the case that (i) profit rates are equalized across countries, i.e. $\pi^c = \pi$, (ii) there are no rents (prices are in equilibrium), (iii) there is no leakage, and (iv) each country is investing only in the own country (no FDI flows). The growth rate can then be calculated as

$$g = \frac{\pi c^r q^r}{c^r q^r} = \pi$$

i.e. the growth rate equals the profit rate.

SECOND CASE: A second solution exists which does not rely on assumptions (i), (ii) and (iv) above but the assumption that investment is allocated across countries according to $\nu^{rs} = c^r q^r / \mathbf{c}^\top \mathbf{q}$. The growth rate becomes

$$g = \frac{\pi \mathbf{c}^\top \mathbf{q}}{\mathbf{c}^\top \mathbf{q}} = \pi.$$

Further, in the case of balanced growth the growth rates of demand equal capacity and output growth rates.

Let us discuss the case in which prices are stable but not in equilibrium. If prices are not in equilibrium rents emerge. If these are fully reinvested or distributed to workers income and investment expenditures are allocated according to the second case above, the equilibrium growth rate becomes

$$g = \frac{(\mathbf{p}^\top - \mathbf{c}^\top)\mathbf{q}}{\mathbf{c}^\top \mathbf{q}}.$$

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